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SOME STUDIES ON STRENGTH PROPERTIES OF CONCRETE WITH PENTA BLENDED CEMENT (MICRO- SIO_2)

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ABSTRACT

Cement has became an integral part of Civilization and the process of production of cement releases green house gases causing global warming and also uses precious natural resources. Pozzolanic materials play an important role to reduce the consumption of cement. The present experimental investigation study focuses on the M20 grade concrete mix was designed and cube compressive strength of 28 days is tested with partial replacement of cement at 0%, 4%, 8%, 12%, 16%, 20% using pulverized quartz powder, silica fume and slag, individually and found that optimum replacement of these materials is 16%. A study was also done with replacement of three numbers of pozzolanic materials in equal proportion in combination with varying percentages of micro-SiO_2 powder at 0.5%, 1%, 1.5%, 2%, and 2.5% on 16% of cement. The study was conducted for compressive strength, split tensile strength and for flexural strength at 7 days and 28 days.

Key words: OPC, Silica Fume (SF), Slag(S), Pulverized Quartz Powder (PQP), Micro-Sio_2 Powder (MSP), Compressive Strength, Split Tensile Strength, Flexural Strength, Penta Blended Concrete, Control Concrete.

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1. INTRODUCTION

Concrete is the most commonly used material in the construction industry. Engineers have been looking for concrete which stronger and more durable against aggressive environment and pozzolana shows different durability properties with the content and type of active silica present in their composition. In relation to the effect of pozzolana on concrete strength, it should be stated that the type, amount and fineness of pozzolana and also the type of cement are the factors that affect the strength of concrete. Pozzolana are used to partially replace cement in concrete, they are often added to concrete to make the mixtures more economical, reduce permeability, increase strength. Typical examples included natural pozzolana likes slag, silica fume, pulverized quartz powder.Pozzolana is a siliceous or alumino-silicious material that, in finely divided form and in the presence of moisture, chemically reacts with the calcium hydroxide that is released by the hydration of Portland cement to form compound processing cementitious properties. Pozzolans react with chemically with calcium hydroxide from hydration of OPC to form CSH. CSH is the strong binder that hardens in concrete. This CSH provide extra cementing material and also fill the pores in concrete, making it possible to reduce quantity of cement.

The pozzolanic materials are classified into two categories. They are natural pozzolana, which are of volcanic origin and man-made pozzolans, which include industrial by-products such as pulverized quartz powder (PQP), Silica Fume (SF), Slag(S). The use of pozzolanic material based blended cement concrete is growing rapidly in the construction industry, which will result in saving of energy, environmental protection and conservation of resources. Pulverized quartz powder, when used in concrete, contributes to the strength of concrete due to its pozzolanic reactivity. However, since the pozzolanic reaction proceeds slowly, the initial strength of pulverized quartz powder (PQP) concrete tends to be lower than that of concrete. Due to the continued pozzolanic reactivity concrete develops greater strength. The pozzolanic reaction also contributes to making the texture of concrete dense.

The addition of Slag in concrete generally reduces the water demand and improves workability. In the case of Slag, the improvement may not be measurable in terms of compaction factor. Slag present in the mix has the physical effect of modifying the flocculation of cement, with resulting reduction in the water demand and heat of hydration. Since the pozzolanic reaction is slow and depends on the calcium hydroxide availability, the strength gain takes longer time. The use of Slag reduces permeability, good resistance to freeze and thaw and controls the alkali silica reaction.

Addition of third super fine blended pozzolana material like Silica fume (SF) improves the compressive strength, split, and flexural strength of concrete at the early ages and reduces the carbonation of concrete because of pore filling and fast pozzolanic reaction. Apart from this, penta blends have excellent durability and rapid development of Strength compared to plain cement concrete and binary blended concrete and also it increases the resistance to chemical attack which minimize the maintenance costs of the concrete elements. To study the effect of blended pozzolana material such as Pulverized quartz powder (PQP) Slag(S) and silica Fume(SF),Micro-SiO_2 powder (MSP) in penta blended concrete cementitious system on the strength characteristics such as cube compressive strength, cylinder Compressive strength, splitting tensile strength, flexural strength.

1.1 LITERATURE REVIEW

Jayobroto Burman Roy (2008) conducted accelerated carbonation study of binary (6% SF) and ternary (15% FA and 6% SF) blended concrete and based on the results it was found that the carbonation depth of ternary blended concrete was low compared to binary and control concrete.

Mullick (2007) has made a detailed review analysis for the use of mineral admixtures like FA, GGBS and SF on durability properties of blended concrete. Based on the analysis, he concluded that the additions of mineral admixtures have render good early performance and greater durability of blended concrete and also observed that the IS code of practices for concrete specifications were not explicit to ternary blends.

Scali et al. (1987) reported that the water demand of concrete containing silica fume increases with increasing amount of silica fume at the stage of fresh concrete**. Osborne (1989)** reported the test results of slump, vee-bee time and compaction factor for concrete containing zero, 40% and 70% GGBS and concluded that when the % of GGBS is increased, the workability properties is reduced.

Gopalakrishnan et al. (2001) conducted experiments on strength and durability of HPC using fly ash as cement replacement material, and reported that the 7-day compressive strength of concrete mixes, having fly ash up to 25 %, is slightly less than that of the control concrete mix, and marginally more than that of the control concrete at 28 days.

Dhir et al. (1997) carried out experiments for developing chloride resisting concrete using Pulverized Fuel Ash (PFA). The PFA concrete mixes were designed to optimize resistance to chloride ingress. They found that up to 33 % PFA level, the chloride binding capacity was the dominant factor in improving the resistance to chloride attack.

Balasubramanian and Krishnamoorthy (2004) observed that the durability properties like water absorption and chloride diffusion were very much improved with the addition of GGBS. The water absorption and chloride diffusion values were lower in the case of slag based concrete mixtures with 7 % cement replacement material level.

Venkatesh Babu and Natesan (2004) conducted some experiments on strength and durability characteristics of silica fume concrete and reported that the values of water absorption are lower for concrete mixes with 2.5 to 15% replacement of cement by silica fume.

2. EXPERIMENTAL PROGRAMME

Materials

2.1. Cement

Ultratech Ordinary Portland Cement(OPC) of 53 grade confirming to IS 12269:1987 with a specific gravity 3.10, initial setting of cement is 4.8 min and final setting of cement is 450 minimum, and fineness modulus of cement is 4%,and normal consistency of cement is 34 and soundness of cement is 5mm was used in this study.

2.2. Fine aggregate

River sand confirming to zone-II of IS 383:1970 having specific gravity, fineness modulus as 2.6, 3.15 was used in the study.

2.3. Coarse aggregate

20 mm graded crushed stone conforming to IS 383:1970 is used as coarse aggregate. Specific gravity of CA is 2.8 and bulk density of CA is 1600kg/m3,water absorption is 0.35%,fineness modulus of CA is 3.951,impact value of CA 16.6%,elongation index and flakiness index as 22.98% and 10.55%,and crushing value is 9.95 was used in the study.

2.4. Silica Fume (SF)

The silica fume is a very fine powder with spherical particles about 100 times smaller in size than those of Portland cement. The particles are extremely fine and having diameter ranging between 0.03 and 0.3 micro meter, with more than 95% of the particle being less than 1 micro meter Silica fume used in this study was obtained from reputed in ASTRRA chemicals Chennai, Pvt.Ltd India. Silica fumes specific gravity.2.63.

2.5. Slag(S)

Slag is very fine powder, specific gravity is 2.85 and white in color, and 100% material was passing through 90 microns sieve. It is used in this study replacement of cement and it's produced from steel plant. It is a by-product from the blast furnaces used to make iron, obtained from JSW, Bellary, India. Surface area fineness of about 400 m2/kg Blaine.

2.6. Pulverized quartz powder (PQP)

Quartz powder is used in glass industry and the fine pulverized quartz with less than 90 micron sieve is disposed off as waste and the sio2 content is 99%, is white in color, with specific gravity 2.68. It's obtained from in Rayalseema mines and minerals Pvt.Ltd, Kurnool, India.

2.7. Micro-SiO2 powder (MSP)

It is obtained from Bottom up Technologies Corporation Pvt.Ltd, Jharkhand, India. It is white in color, Specific gravity 1.3, and passing through 90 micron sieve, molecular weight 60.08, purity is 99%, and PH value 9, dispersion in water, and texture is white milky liquid. The micro-SiO_2 powder was mixed with OPC during 5 minutes in order to increase dispersion.

2.8. Chemical Admixture

Super plasticizer should conform to IS 9103:1999.Super plasticizer PLAXEM obtained from Peagus company available as medium brown colored aqueous solution is used to increase the workability of concrete and as water reducing agent to achieve required workability. The specific gravity and pH value is 1.1 and 7.

2.9. Water

Any water conforming to IS 456:2000 is suitable for producing concrete and curing concrete.

3. MIX PROPORTIONS

An experimental investigation M20 grade concrete with different percentages replacement levels (0, 4, 8, 12, 16, 20) of silica fume, pulverized quartz powder, slag and next levels with different percentage of micro-SiO_2 powder (0.5,1,1.5,2,2.5).The mix design procedure adopted according to IS 10262:2009&IS 456:2000

Table 1 M20 grade mix proportions.

CEMENT (Kg/m^3)	FA(Kg/m^3)	CA(Kg/m^3)	WATER(kg/l)
375	680	1300	186

4. TABLES AND GRAPHS

Table 2 Cement replacement with slag (Binary mix)

Mix	cube compressive strength in N/mm^2		% increase or decrease in control	
	7 days	**28 days**	**7 days**	**28 days**
CM	21.63	29.16	0	0
S-4	26.60	33.48	22.97	14.81
S-8	28.81	34.81	33.19	19.37
S-12	29.33	35.55	35.59	21.91
S-16	**33.33**	**43.55**	**54.09**	**49.17**
S-20	30.22	35.33	39.71	21.15

Table 3 Cement replacements with SF (Binary mix)

Mix	cube compressive strength N/mm^2		% increase or decrease in control	
	7days	**28 days**	**7days**	**28 days**
CM	21.63	29.16	0	0
SF-4	24.74	31.26	14.37	7.20
SF-8	27.36	33.33	26.49	14.30
SF-12	29.24	35.39	35.18	21.36
SF-16	**33.03**	**41.27**	**52.70**	**41.52**
SF-20	30.96	37.45	43.13	28.42

Table.4 cement replacement with pulverized quartz powder (Binary mix)

Mix	cube compressive strength N/mm^2		% increase or decrease in control	
	7days	**28 days**	**7days**	**28 days**
CM	21.63	29.16	0	0
PQP-4	27.55	35.55	27.36	21.91
PQP-8	29.77	37.55	37.63	28.77
PQP-12	32.00	38.36	47.94	31.55
PQP-16	**33.33**	**40.88**	**54.09**	**40.19**
PQP-20	28.22	36.88	30.46	26.47

Table .5 16% replacement of cement with (SLAG+SilicaFume+Pulverised quartz powder) in equal proportions (Tetra blend)

Mix	cube compressive strength N/mm^2		% increase or decrease in control	
	7days	28 days	7 days	28days
16% (S+SF+PQP)	32.66	39.33	50.99	34.87

Table 6 Penta blended concrete Cube compressive strength with micro-SiO_2 powder at varying percent replacement at 0.5%-2.5% on 84% of cement

MIX	Cube compressive strength		%increase or decrease in control	
	7days	28 days	7days	28 days
CM	21.63	29.16	0	0
MSP-0.5	31.55	35.11	45.86	20.40
MSP-1.0	**34.51**	**42.00**	**59.54**	**44.03**
MSP-1.5	32.00	36.00	47.94	23.45
MSP-2.0	29.33	34.81	35.59	19.37
MSP-2.5	24.88	32.00	15.02	9.73

Table 7 Penta blended concrete cylinder compressive strength with micro-SiO_2 powder at varying percent replacement at 0.5%-2.5% on 84% of cement

Mix	Cylinder compression strength N/mm^2		%increase or decrease in control	
	7 days	28 days	7 days	28 days
CM	16.79	18.49	0	0
MSP-0.5	14.28	16.41	-14.94	-11.24
MSP-1.0	18.10	20.93	7.80	13.19
MSP-1.5	17.12	19.80	1.96	7.08
MSP-2.0	16.38	18.67	-2.44	0.97
MSP-2.5	13.58	16.92	-19.11	-8.49

Table 8 Penta blended concrete cylinder Split tensile strength with micro-SiO_2 powder at varying percent replacement at 0.5%-2.5% on 84% of cement

MIX	Cylinder split tensile strength N/mm^2		%increase or decrease in control	
	7 days	28 days	7 days	28 days
CM	2.83	3.35	0	0
MSP-0.5	1.98	2.32	-30.03	-30.74
MSP-1.0	**2.86**	**3.54**	**1.06**	**-68.35**
MSP-1.5	2.67	2.98	-5.30	-11.04
MSP-2.0	2.40	2.83	-15.19	-15.52
MSP-2.5	2.12	2.70	-25.08	-19.40

Table 9 Penta blended concrete flexural strength with micro-SiO_2 powder at varying percent replacement at 0.5%-2.5% on 84% of cement

Mix	Flexural strength N/mm^2		%increase or decrease in control	
	7 days	28 days	7 days	28 days
CM	2.8	3.16	0	0
MSP-0.5	2.75	3	-1.78	-5.06
MSP-1.0	4.57	5	63.21	58.22
MSP-1.5	3.27	3.8	16.78	20.25
MSP-2.0	2.78	3.5	-0.71	10.75
MSP-2.5	1.98	2.83	-29.28	-10.44

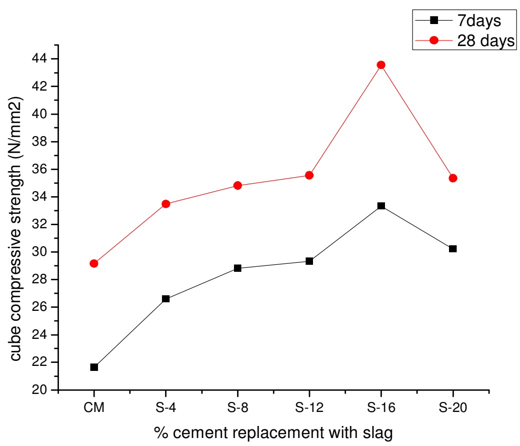

Figure 1 % of cement replacement with slag 7 days and 28 days cube compressive strength

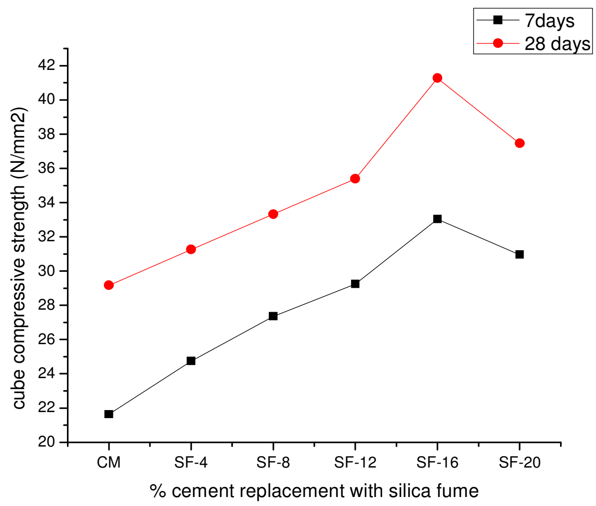

Figure 2. % of cement replacement with Silica fume 7 days and 28 days cube compressive strength

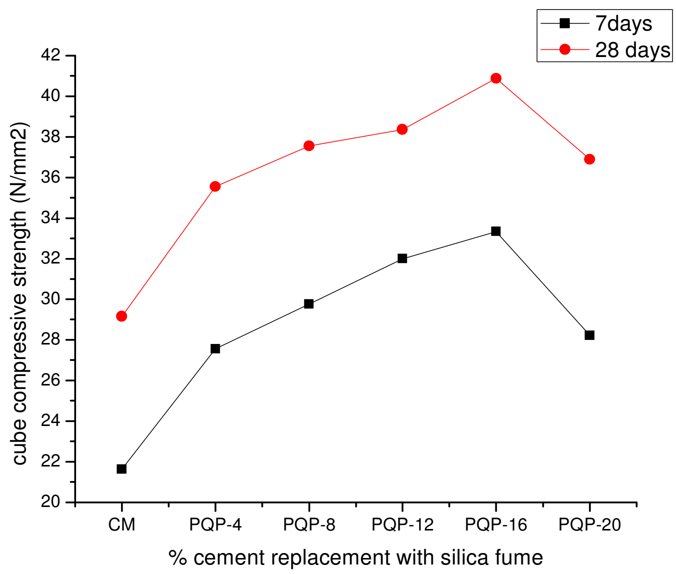

Figure 3 % of cement replacement with pulverized quartz powder 7days and 28 days of cube compressive strength

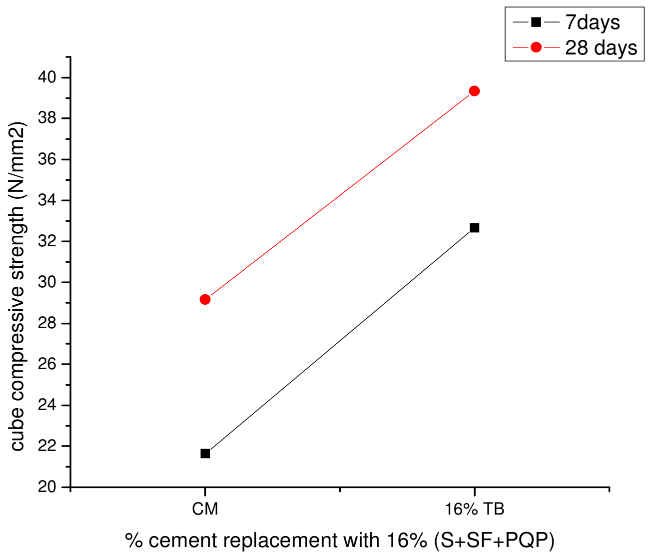

Figure 4 16% of cement replacement with tetra blended(S+SF+PQP)

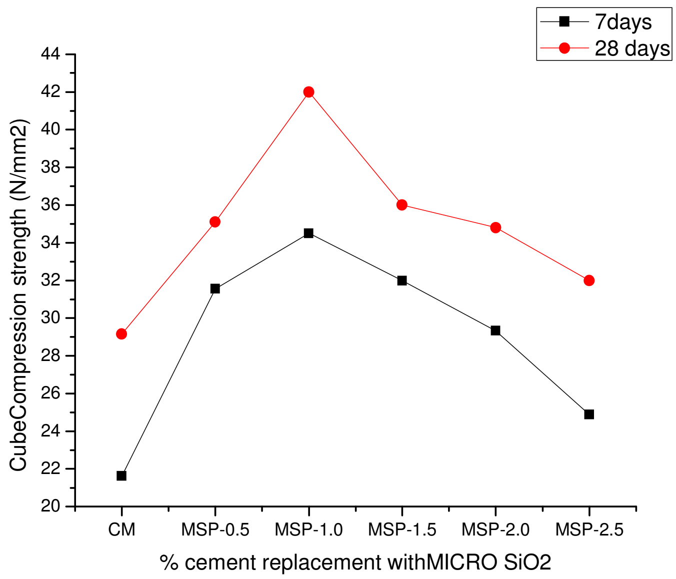

Figure 5 compressive strength of cubes at various % of micro-sio2 powder 7&28 days

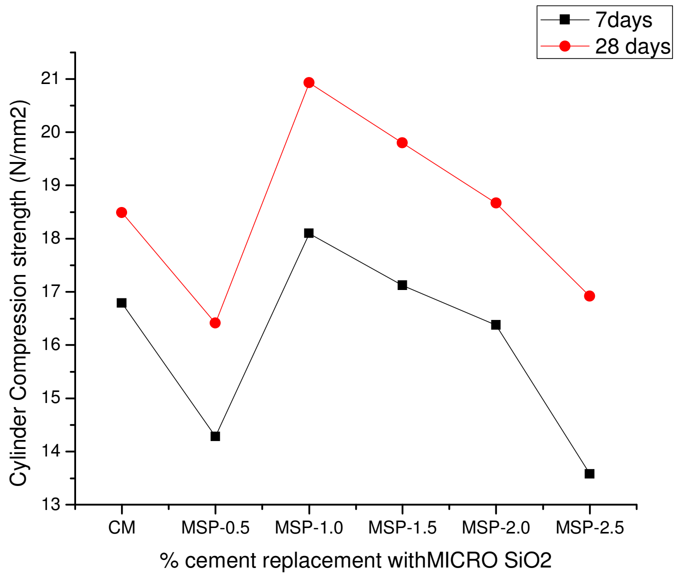

Figure 6 Cylinder compressive strength of micro-sio2 powder with various proportions of 7 day and28 days

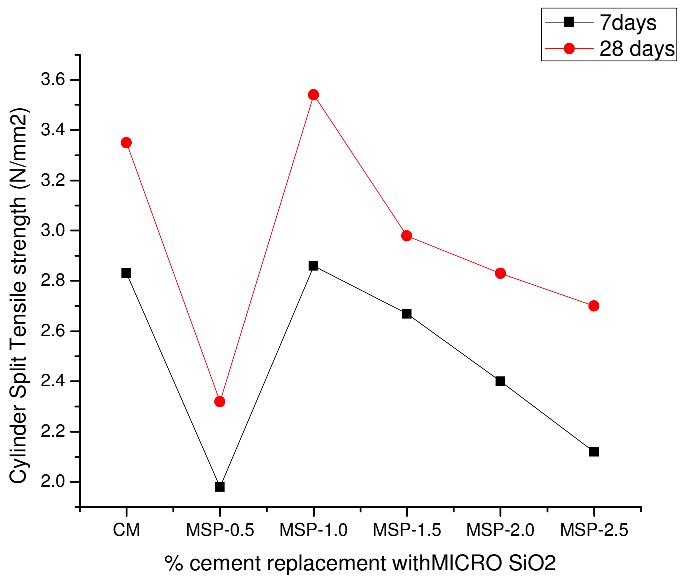

Figure 7 split tensile strength of cylinder at various micro-sio2 powder 7&28 days

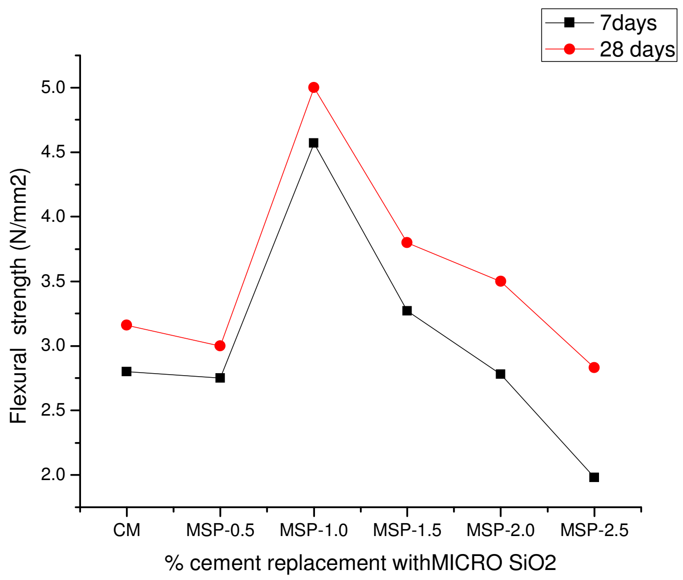

Figure 8 flexural strength of beam at various proportion of micro –sio2 powder

RESULT AND DISSCUSSION

1. The cube compressive strength, cylinder compressive strength, split tensile strength and flexural strength of M_{20} concrete is 29.16 N/mm^2, 18.49 N/mm^2, 2.32 N/mm^2, and 3.16 N/mm^2.
2. The cube compressive strength with 16% replacement binary mix with slag, Silica fume and pulverized quartz powder is 43.55, 41.27 and 40.88N/mm^2 respectively. The increase in Cube compressive strength over M_{20} is about 49.17%, 40.19% and 41.52%.
3. 28 days cube compressive strength of tetra blended (Slag Silica fume+Pulverised quartz powder) concrete is 39.33N/mm2 and the increase is about 34.87% over M_{20} mix.
4. The cube compressive strength of Penta blended concrete containing constant 16 % of three numbers of pozzolanic materials (Slag+Silicafume+Pulverised quartz powder) and varying amount of micro-SiO2 powder i.e. 0.5%, 1%, 1.5%, 2%, 2.5% on 84% of cement is 35.11,42,36,34.81,32 N/mm2 respectively.
5. The split tensile strength age of 28 day of curing penta blended concrete containing constant 16%(S+SF+PQP) and varying amount of micro-SiO2 powder i.e. 0.5%, 1%, 1.5%, 2%, 2.5% having maximum strength is 2.32,3.54,2.98,2.83,2.70N/mm2 respectively at 1% replacement of Micro sio2 powder with penta blended concrete of cylinder split tensile strength is 3.54N/mm2 as compared to -68.35% decreased in control concrete.
6. The flexural strength age of 28 days of curing penta blended concrete containing constant16%(Slag Silica fume+Pulverised quartz powder) and varying amount of micro-SiO2 powder i.e. 0.5%, 1%, 1.5%, 2%, 2.5% having maximum strength is 3, 5, 3.8, 3.5, 2.83 N/mm2 at 1% replacement of Micro-sio2 powder in penta blended concrete of flexural strength is 5 N/mm2 as compared to 58.22% increased in control concrete.
7. The cylinder compressive strength of penta blended concrete containing constant16%(Slag Silica Fume+Pulverised quartz powder) and varying amount of micro-SiO2 powder 0.5%, 1%, 1.5%, 2%, 2.5% having maximum strength 16.41,20.93,19.80,18.67,16.92N/mm2 at 1% replacement of Micro-sio2 powder in penta blended concrete is 20.93 N/mm2.

CONCLUSIONS

From the information presented in this paper, the following conclusions can be drawn:

1. In the case of binary blended cement with pozzolanic materials with 16% replacement of cement by Slag, Silica fume, Pulverized quartz powder, the 28 days of maximum compressive strength is 43.55N/mm^2, 40.88N/mm^2 and 41.27 N/mm^2 respectively.
2. In the case of tetra blended cement (16% replacement of cement) with three number of pozzolanic materials in equal proportions i.e., Slag, Silica fume, Pulverized quartz powder, the 28 days maximum compressive strength is 39.33N/mm2 which is less than the Binary blended cement concrete.
3. In the case of Penta blended concrete with micro-SiO_2 powder at 1% on 84% of cement gives the optimum results for compressive strength, split tensile strength, flexural strength, and cylinder compressive strength.

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